as there are no stations equipped with the necessary apparatus within the section, but at the central office of the Weather Bureau at Washington, which was considerably out of the path of the storm, a wind velocity of 36 miles was recorded at 3 p. m.

At this same time the barometric pressure was 29.87 inches, which rose rapidly to 29.96 within 15 minutes, but fell to 29.86 inches at 4 p. m.

Within a period of less than 15 minutes the wind had fallen and a perfect calm prevailed, with a clearing sky. The rainfall at three cooperating stations—Cheltenham, La Plata, and Ferry Landing—was 0.38, 0.34, and 0.19 inches, respectively, and during the night there were about 2 inches of additional rainfall. Hail also was quite general over the area, some places east of Washington reporting stones as large as walnuts. A light hail fell in Washington at the beginning of the storm.

In St. Marys and Charles Counties the most destructive wind was from the northwest, while in Prince Georges County the wind was most severe from the southwest. In Calvert County, on the east side of the Patuxent River, the writer found that both the southeast and northwest winds did about equal damage. In some localities large trees were twisted off and scattered in all directions, which would possibly indicate tornadic action; but otherwise the storm as a whole was a straight-line blow.

At Cheltenham an entire piece of virgin forest, consisting of large oaks of several feet in diameter, was completely blown down. At the same place a church was completely moved from its foundations while filled with people. Very few homes were destroyed, most of the damage being confined to porches and roofs, but trees, many of them a century old, around practically every house in the path of the storm were uprooted.

Tobacco barns met with destruction throughout the area, and this is the direct cause of the high monetary losses, as practically every barn was partially filled with cured tobacco awaiting shipment.

In Calvert County there were 64 tobacco barns destroyed, with a loss of over $60,000 for the buildings alone, as no tornado insurance is carried in that part of the East. The loss of cured tobacco will probably amount to $100,000 in this county. In Prince Georges County approximately 80 barns were destroyed, with a loss of over $200,000, while in St. Marys and Charles Counties over 50 barns and contents were destroyed, with a loss of $150,000. The loss of orchards, fruit, stock, fences, timber, etc., will approximate $100,000.

In many cases entire orchards were uprooted, the writer having seen one with the trees blown over in rows with perfect precision. Hundreds of telephone poles were down, and the mass of trees, branches, poles, and wire made public roads impassable for several days. The loss to public-service companies will run into many thousands of dollars.

At Chesapeake Beach, a summer resort on the east side of the bay, in Calvert County, which was crowded with patrons, considerable damage was done by the destruction of cottages, piers, and boardwalk. Falling trees and limbs wrecked a large number of parked automobiles and endangered the lives of the occupants. A number of lives, estimated to be about 10, were lost, mostly when boating parties on the Potomac, Patuxent, and Chesapeake were caught in the storm.

A church, located in a deep valley and surrounded by high wooded hills and filled with colored worshippers, was lifted into the air and dropped some distance from its foundations, demolishing the plastering and windows, while at the same time a horse and buggy standing near the door were blown over a fence into a creek.

One peculiarity of the storm was that the level country bordering the Patuxent River, on the west and east, was singularly free from damage, while the sections back from the river received the entire brunt of the storm. The water on the eastern side of the Patuxent River, which is over one-half mile wide at this point, was backed up so that it overflowed and washed away the surfacing from a road which parallels the river.

At one place the writer noticed a barn which had been blown down by the southwest wind and a scant quarter of a mile off to the east another barn blown down by a northwest wind. A large oak tree was uprooted but a few feet from the door of a public-school house, while smaller trees in the rear of the building were untouched, not even having branches broken off. Reports of streaks of severe wind velocities of this kind were very common.

This storm, covering much of the tobacco belt of southern Maryland, strikes a severe blow to the farmers who raise only tobacco of the famous Maryland type. The loss of over one-half of the great barns in this section will prevent many farmers from growing tobacco this season, as it will be impossible to reconstruct the buildings for the housing of the 1924 crops, which begins with August 1.

RECORD CLOUDBURST FLOOD IN CARTER COUNTY, TENN., JUNE 13, 1924

By WARREN R. KING, District Engineer, U. S. Geological Survey

One of the most terrific rainstorms ever recorded in eastern Tennessee descended upon the small mountain villages of Cardens Bluff, Siam, and Hunter and the surrounding region in Carter County during the night of June 13, 1924. This torrential cloudburst caused the loss of 11 lives, severely injured several persons, and damaged property to the extent of more than half a million dollars. The scene of the disaster lies just east of Elizabethton, along Watauga River, about 20 miles east of Johnson City.

The greatest devastation was wrought in a nearly oval area containing about 50 square miles, the major axis of which extends from northwest to southeast between Hunter and Cardens Bluff. Within this area roads and highways were rendered impassable, many sections being completely washed out and bridges destroyed; houses were swept away; and hundreds of acres of farm land were covered with rock and débris. The mountain division of the Southern Railway, which runs parallel to Watauga River throughout this area, suffered heavy damage. In at least 50 places the track was either swept into the river or was covered with 1 to 5 feet of earth and rock, and many bridges and trestles were washed away. The railroad officials detailed more than 500 men to clear up the wreckage and rebuild the track, and within 6 days after the storm trains were again running on schedule time.

Owing to the comparatively small size of the area covered by the storm, there was no extreme flood on either Watauga River or Doe River, whose channels were more than adequate to carry the flood water, and the bulk of the damage came from floods on small tributaries and from hillside wash.

The storm was caused directly by two extremely heavy rain clouds, one traveling from the northwest, the other from the southwest, meeting almost at a right angle at the same altitude and discharging their load at that point. Either cloud in itself would have produced a heavy rainfall over the area, but, owing to the collision, the condensation of water vapor was extremely rapid. The storm was accompanied by a tremendous display of lightning and deafening thunder.[14]

Those who saw the storm say that not only was there a most intense general rain over the region, but that at many places the clouds broke as if punctured and discharged perfect streams of water. The truth of this statement is shown by deep gashes or scars, almost resembling cuts from a hydraulic jet, that were cut into the hillsides at places where there had been no depression or watercourse. The torrents and landslides that cut these gashes carried everything with them to the foot of the slopes, leaving the underlying rock entirely bare. (See figs. 1–3.)

The region is one of very steep slopes and most of it is heavily timbered. A slide once started gained momentum rapidly and struck with tremendous force. Some single slides carried thousands of tons of rock, earth, trees, and débris down to the lowlands and into the river channel. The hillside scars left by these slides range in width from 10 to 100 feet, and from some points no less than a dozen of them can be seen.

Immediately on learning of the flood the writer, accompanied by P. P. Livingston and D. B. Ventres, of the Chattanooga office of the United States Geological Survey, started for Elizabethton. The party arrived there about 1 p. m. on Sunday, June 15, and collected such information as could be obtained concerning the nature and extent of the storm and the run-off.

Gaging stations are operated by the United States Geological Survey in cooperation with the United States Engineers Corps and the Tennessee Geological Survey at the following points in this region:

South Fork of Holston River at Bluff City, Tenn.
Watauga River at Butler, Tenn.
Watauga River at Elizabethton, Tenn.
Doe River at Valley Forge, Tenn.

Each of these stations was visited as soon as possible, discharge measurements were made by means of current meters, the water surface was marked, and high-water marks were placed in the vicinity. Level lines were afterward run to determine the slope of the water surface at the time of the measurements and the slope of the high-water lines for a length of about 1,000 feet both ways from each gaging station. Complete cross sections were obtained at each gaging station up to the high-water line. Most of the cross sections at the gaging stations were typical of particular stretches of the rivers, and as the streams were still high and no boats were available no other cross sections could be taken. It is believed, however, that for a rough approximation, which is all that was desired, no serious error was introduced because additional cross sections were not taken at other points.

From the discharge measurements and the slope of the water surface at the time, the value of the coefficient n in Kutter's formula was obtained at each point, and from the high-water slope and cross sections, with the value of n thus derived, the crest discharge was computed.

There are three standard rain gages in the vicinity—two owned by the United States Weather Bureau at Bluff City and Elizabethton and one at the plant of the Watauga Power Co. above Siam. The rainfall for the storm recorded at these points was 1.62, 1.00, and 11.24 inches, respectively. At all other points data as to the rainfall and its distribution were obtained by traveling over the storm area and noting the precipitation in tubs, jars, buckets, or other receptacles, that were standing out in the open air in such a position as to catch the normal rain and by making careful inquiry of the residents as to whether these receptacles had contained any water before the storm or whether thay had been disturbed afterwards. All this information was obtained within four days after the storm, during which there had been no more rain. No account was taken of evaporation, which might well have amounted to several hundredths of an inch, as the days had been warm and sultry. Considerable care was taken to get correct data, and check observations were obtained wherever possible. The greatest rainfall was found at Cardens Bluff, where on June 17, three days after the rain, a depth of 14.98 inches was measured in a 20-gallon stone crock standing in an open space 25 feet from a farm house. This crock had been washed and set out in the sun to dry late in the afternoon preceding the storm and had not been molested subsequently.

According to statements of the inhabitants living in the center of the devastated area, the storm began at about 6:30 p. m. in the form of violent hail, which lasted only a few minutes; then a very heavy rain set in, which continued without interruption or abatement until 10 o'clock, approximately three and one-third hours. It then subsided appreciably, although not altogether, until 12:30 a. m., when a second hard rain began that lasted until 2:30 a. m. June 14. By far the greater part of the rain fell during the first storm; in fact, the observations indicate that at least 12 inches of the 15 inches recorded at Cardens Bluff fell during that period of three and one-third hours. At Siam and at the power plant, where the rainfall amounted o about 11 inches, there was no second storm, and this entire amount fell in three and one-half to four hours, as is further indicated by head-water readings taken at the power plant each hour during the night. These readings are given below:

June 13, 1924:	Head-water gage	June 14, 1924:	Head-water gage
6 p. m.	0.1	1 a. m.	3.8
7 p. m.	.1	2 a. m.	3.6
8 p. m.	3.6	3 a. m.	3.3
9 p. m.	4.8	4 a. m.	3.2
10 p. m.	6.0	5 a. m.	3.2
11 p. m.	5.4	6 a. m.	3.2
12 p. m.	4.1	7 a. m.	3.2
		8 a. m.	3.1
		9 a. m.	3.1
		10 a. m.	3.0

It will be noted that the crest of the run-off occurred at this point about 10 o'clock in the evening * * *

A line of levels was run to determine the maximum height of the river above the crest of the Watauga Power Co.'s dam, and it was found to be 6.24 feet. Flash boards 3 feet high, which were on the dam before the storm, failed early in the storm, owing to the immense quantity of heavy drift, leaving only one short section, about 25 feet in length, which was badly damaged. The spillway section of this dam is of the gravity type, with a rounded crest, on which a coefficient of 3.40 was used

[14] Eastern Tennessee on the evening of June 13 was just within a region of unsettled weather with local thunderstorms. The barometer was low generally from the lower Missouri Valley eastward to the Atlantic and there were two areas of still lower pressure within the general area, one over North Carolina, the other over southern Illinois. The winds over North Carolina and eastern Tennessee were light and mostly southerly. The appearance of two clouds meeting may have been more apparent than real. The torrential rain was doubtless the result of violent vertical convection in warm moist air currents that prevailed at the time and place.—*Editor.*

FIG. 1

FIG. 2

FIG. 3

in the Francis weir formula to determine the discharge. It is assumed that the maximum stage of 6.24 feet occurred about 9:45 p. m., the discharge at that time being 12,000 cubic feet per second. It is believed that the flow up to that time came from a point below the mouth of Cobb Creek, which is 9 miles upstream from the dam. The drainage area between the mouth of Cobb Creek and the power dam as measured from the topographic map is 32 square miles, and the run-off was therefore 375 second-feet to the square mile.

The drainage area, including Cobb Creek and everything below Butler, would be 46 square miles, and the maximum rate of run-off would be correspondingly reduced to 261 second-feet to the square mile if Cobb Creek is assumed to have contributed to this peak discharge. It is reasonably certain that the flow above Butler did not enter into this rate of discharge, as it would require an average velocity in Watauga River of 5 feet a second for the flow at Butler to reach the Watauga Power Dam in three hours, and the maximum flow at the dam occurred three hours after the rain began. It seems more than probable that this maximum discharge was derived entirely from the area below Cobb Creek.

The maximum discharge at the dam and other points in this region, as determined by this investigation, is given below.

Stream	Location	Gage height (feet)	Discharge (second-feet)	Drainage area included (square mile)	Run-off (second-feet per square mile)
Watauga	Butler	5.71	6,500	[1] 427	15.2
Watauga	Power dam	6.24	12,000	32	375
Watauga	Elizabethton	13.40	30,000	270	111
Doe	Valley Forge	6.70	5,000	[1] 132	37.9
South Fork of Holston River.	Bluff City	7.25	8,800	[1] 828	10.6

[1] Total drainage area of stream.

An attempt was made to obtain data on the run-off of some of the smaller tributaries that lie wholly within the region of highest rainfall, but on all such streams the slope was so steep and the amount of rock, trees, and other débris carried by the floods so great that nothing resembling an accurate estimate of maximum run-off was possible. All hope of getting any such figures was therefore abandoned. A very striking illustration of this point is the small ravine at Cardens Bluff, where two houses were demolished and nine of the occupants drowned. A careful examination of this ravine indicates that its total catchment area does not exceed 15 acres. One of the inhabitants who escaped stated that a wall of water, rock, and earth 8 to 10 feet in height crashed into these houses without perceptible warning, totally wrecking them. He himself was thrown 30 feet or more by the force of the blow and was severly injured.

The accompanying illustrations (figs. 1, 2, and 3) show something of the force of this record cloudburst and the resulting damage.

No accurate estimate of the damage to property has been made, but the best information available indicates that it was at least half a million dollars.

NOTES, ABSTRACTS, AND REVIEWS

TROPICAL CYCLONES

[Reprinted from Nature, London, June 28, 1924, p. 939]

In his presidential address to the Section of Physics and Mathematics of the Tenth Indian Science Congress, Dr. S. K. Banerji reviewed the present position of our knowledge regarding the origin and causes of tropical cyclones. The contributions to this branch of meteorology of Hann, Lodge, Dines, Bjerknes, and Shaw are considered and none of them found to give a satisfactory explanation of the phenomena. The recent work of Shaw contained in his essay "The Birth and Death of Cyclones" naturally received the most attention.

Doctor Banerji considers that the air currents on the two sides of the "trough of low pressure" which exist over northern India during the monsoon may be the origin of the storms which form at the head of the bay during that season, but he is unable to accept Shaw's explanation of the subsequent development and progress in the development of the theory of cyclones, but considers that many more data, especially from the upper air, are required before much further progress can be made.

LIGHTNING EXPLODES DYNAMITE

Six men were instantly killed at a rock quarry 7 miles south of Winston-Salem, N. C., on June 24, 1924.

The men had sought shelter from a passing electric storm in a temporary office structure in which was stored a quantity of dynamite. Lightning struck a near-by tree and in some manner not clearly understood, exploded the dynamite. The office structure was fired, as were also the inflammable parts of an automobile that was parked near by. The bodies of the men were badly mangled and burned. The explosion was witnessed by persons at a distance.—*News-Observer*, Raleigh, N. C.

WEATHER CONDITIONS IN THE POLAR REGIONS AND AMUNDSEN'S POLAR FLIGHT

[Reprinted from "The Meteorological Magazine," 59, No. 701, June, 1924, p. 1157.]

In the Tidens Tega for March, 1924, there was an account of the weather conditions in the north polar region, written by Doctor Hesselberg in view of Amund-